Ontario

Apprenticeship
In-school Curriculum Standards

Instrumentation and Control Technician

Level III

447A

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Introduction

This Instrumentation and Control Technician Curriculum Standard has been developed in keeping with the Common Format Guidelines prescribed by the Ministry of Training Colleges and Universities (MTCU) from the trade workplace Performance Objectives (447A). The curriculum standard reflects the content necessary for appropriate progression through each level of the Instrumentation and Control Technician in-school apprenticeship program.

For easy reference, a time allocation has been included for each respective reportable subject and units, along with a breakdown of theory and application in the delivery of the performance objectives.

The continual introduction of innovative techniques and more complex equipment is resulting in increasing demands for service technicians who are not only skilled in the practical aspects of the trade, but who also have a sound theoretical knowledge of the testing, diagnosing and servicing requirements. The curriculum standard has been developed to provide this theoretical knowledge and to offer some practical applications to complement the on-the-job work experience of the Instrumentation and Control Technician.

The curriculum standard has been designed to give the instructor every opportunity for flexibility and innovation without significant departures from content. Since the scope of the prescribed curriculum standard is quite extensive, the apprentice will be expected to reinforce the acquired knowledge through regular independent out-of-classroom assignments.

The curriculum standard includes specific references to the apprenticeship on-the-job training standards. While terminal performance objectives in the training standards have been linked to the respective in-school learning outcomes and learning content objectives, employers should not assume complete coverage in all aspects of the objectives. The in-school delivery focuses primarily on the knowledge required and fundamental skills that support the respective performance objectives outlined in the workplace training standards. Employers are expected to complete the delivery of these objectives by applying the prescribed in-school knowledge to the practical learning experiences in the work setting.

Regular evaluations of an apprentice's learning achievements must be performed in both theory and practical applications throughout the program.

PROGRAM SUMMARY OF REPORTABLE SUBJECTS

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practice
S0380	Applied Circuits	42	24	18
S0381	Programmable Logic Controllers & Distributed Control Systems	57	14	43
S0382	Instrumentation and Controls II	75	47	28
S0383	Analytical Instrumentation	36	30	6
S0384	Fluid Power Systems	30	22	8
	Total	**240**	**137**	**103**

Program Summary by Reportable Subject & Evaluation & Testing

Number:	**S0380**	
Title:	**Applied Circuits**	
Duration:	Total Hours:	42
	Theory:	24
	Practical:	18

Prerequisites: None
Co-requisites: None

Evaluation Structure:

- Assignments related to theory and appropriate application skills.
- Final exam at end of term.
- Periodic quizzes.

Theory Testing	50%
Practical Exercises	20%
Final Assessment	30%

Number: S0380.1

Title: Solid State Devices

Duration: Total Hours 6

Theory: 6
Practical: 0

Cross-Reference to Training Standard Performance Objectives: 6433.03

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to identify symbols and explain the operation of solid state devices.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

1.1.1 Identify the symbols used for solid state devices such as:

- Silicon Controlled Rectifiers, Triacs
- Operational Amplifiers
- Optocoupler

1.1.2 Explain the operating principles of solid state devices such as:

- Silicon Controlled Rectifiers, Triacs
- Operational Amplifiers
  - explain the operation of a constant current generator
  - explain the term impedance
  - explain the operation of a current source
  -
- Optocoupler

Number: S0380.2

Title: Power Supply, Regulation and Amplifiers

Duration: Total Hours 14

Theory: 6
Practical: 8

Cross-Reference to Training Standard Performance Objectives: 6422.03, 6423.09

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to test and troubleshoot voltage regulation of power supplies and amplifier performance according to manufacturer's recommendations and specifications.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

1.2.1 Describe the function of components of voltage regulators, power supplies and amplifier components.

1.2.2 Explain the operating principles of a power supply regulation circuit.

1.2.3 Explain the operating principles of operational amplifier circuits such as:
- Constant current source
- Inverting
- Non- Inverting
- Voltage Followers
- Summers
- Subtracters
- PID
- Integrator
- Differentiator

1.2.4 Test and troubleshoot power supplies and power supply regulators.

1.2.5 Test and troubleshoot open collector outputs.

1.2.6 Test and troubleshoot operational amplifier circuits.

Number: S0380.3

Title: Switching Circuit Devices

Duration: Total Hours 6

Theory: 4
Practical: 2

Cross-Reference to Training Standard Performance Objectives: 6424.0, 6425.0, 6426.0, 6427.0, 6428.0, 6429.0, 6430.0, 6431.0, 6432.0, 6433.0, 6434.0

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to test and troubleshoot switching devices according to manufacturer's recommendations and specifications.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

1.3.1 Describe the electrical characteristics of switching circuit devices such as:

- Relays
- Opto devices
- Transistors
  - sinking
  - sourcing

1.3.2 Explain the operating principles of switching circuit devices such as:

- Explain the operation of different types of relays
- Explain the operation of different Opto devices used in switching circuits
- Explain the operation of transistors used in switching circuits

1.3.3 Test and troubleshoot switching devices.

Number: S0380.4

Title: Manufacturer's Connection Schematics and Diagrams

Duration: Total Hours 7

Theory: 4
Practical: 3

Cross-Reference to Training Standard Performance Objectives: 6423.01, 6423.09, 6429.16

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to trace and interpret schematics and diagrams for motor drives according to manufacturer's recommendations and specifications.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

1.4.1 Identify manufacturer's connection schematics and diagrams for:

- Process Loops
- DC drives
- AC drives

1.4.2 Trace and interpret the circuits of manufacturer's connection schematics and diagrams for:

- Process Loops
- DC drives
- AC drives

Number: S0380.5

Title: Final Control Elements

Duration: Total Hours 9

Theory: 4
Practical: 5

Cross-Reference to Training Standard Performance Objectives: 6429.01, 6429.02, 6429.03, 6429.04, 6429.05, 6429.06, 6429.07, 6429.08, 6429.09, 6429.10, 6429.11, 6429.12, 6429.13, 6429.14, 6429.15, 6429.16, 6429.17, 6429.18

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to demonstrate the ability to configure, connect and test control wiring for final control elements according to manufacturer's recommendations.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

1.5.1 Describe the construction features of final control elements such as:

- Chemical metering pumps
- Servomotors
- Variable frequency drives (VFD's)

1.5.2 Explain the operating principles of final control elements such as:

- Chemical metering pumps
- Servomotors
- Variable frequency drives (VFD's)

1.5.3 Configure, connect and test control wiring for final control elements such as:

- Chemical metering pumps
- Servomotors
- Variable frequency drives (VFD's)

S0380: RECOMMENDED MINIMUM EQUIPMENT:

- Standard screwdrivers, Phillips screwdrivers, prototype board, side cutters, wire stripper, soldering iron
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, DC amps (0 – 2A),
  AC amps (0 – 10A)
- Variable DC power supply – 0 to 40 Vdc
- Variety of capacitors, inductors, transformers
- Oscilloscope and X10 probe
- AC source – 120 vac
- Assorted resistors
- Prototype board – Circuit assembly
- Clamp-on ammeter
- Lead wire
- Variety of diodes, bridge rectifiers, voltage regulators
- Variety of final control elements (Triacs, SCRs, VFD, etc)
- Operational amplifiers
- Optocouplers
- Variety of relays, contactors,

Number: **S0381**

Title: **Advanced Programmable Logic Controllers and Distributed Control Systems**

Duration: Total Hours: 57

Theory: 14
Practical: 43

Prerequisites: None
Co-requisites: None

Evaluation Structure:

- Assignments related to theory and appropriate application skills.
- Final exam at end of term.
- Periodic quizzes.

Theory Testing 15%
Practical Exercises 55%
Final Assessment 30%

Number: S0381.1

Title: PLC and DCS Control Systems

Duration: Total Hours: 40

Theory: 10
Practical: 30

Cross-Reference to Training Standard Performance Objectives: 6431.01, 6431.02, 6431.03, 6431.04, 6431.05, 6431.06, 6431.07, 6431.08

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to configure and program Programmable logic controllers (PLC) and Distributed Control Systems (DCS).

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

2.1.1 Describe the architecture and operation of advanced control systems.

- Programmable Logic Controllers (PLC)
- Distributed Control Systems (DCS)
- Explain the concept of scaling of analog signals

2.1.2 Plan and organize a DCS/PLC project.

- Select required hardware
- Select programming format

2.1.3 Use HMI (human-machine interface) and MMI (man-machine interface) to display data and control processes.

2.1.4 Configure and program Programmable Logic Controllers (PLC) and Distributed Control Systems (DCS).

- Identify the appropriate DCS/PLC I/O cards for field function and connections
- Configure bus structures for the DCS/PLC controllers and I/O modules

- Identify and manipulate the numerical information as required for DCS/PLC functions such as:
  - Scaling
  - Signal conditioning
- Program graphical user interfaces (GUI) using other various software for a DCS/PLC
- Configure DCS/PLC multi-loop control strategies.

Number: S0381.2

Title: DCS/PLC Control Problem Solving Techniques

Duration: Total Hours: 18

Theory: 4
Practical: 13

Cross-Reference to Training Standard Performance Objectives: 6423.09, 6431.02, 6431.04

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to troubleshoot DCS/PLC system problem solving techniques.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

2.2.1 Plan and organize a DCS/PLC project using standard function block and ladder nomenclature.

2.2.2 Apply diagnostic software tools to solve DCS/PLC problems.

2.2.3 Troubleshoot DCS/PLC systems.

2.2.4 Troubleshoot realistic industrial PLC control problems using logic instructions such as: timing and counting instructions.

- Timers
- Counters
- Latches

S0381: RECOMMENDED MINIMUM EQUIPMENT:

- PLC (Programmable Logic Controller) – minimum 6 discrete inputs, 4 discrete outputs, 2 analog inputs, 2 analog outputs
- DCS (Distributed Control System) – minimum 6 discrete inputs, 4 discrete outputs, 2 analog inputs, 2 analog outputs
- DMM, lead wire
- DC power supply
- AC power source
- Personal computer for program entry c/w PLC software, network card
- Variety of input devices – manual and automatic switches, 4 – 20 mA transmitters
- Variety of output devices – lights, motors, relays and solenoids, 4 – 20 mA loads such as I/P
- Network cables, hub or router

Number: **S0382**

Title: **Instrumentation and Controls II**

Duration: Total Hours 75

Theory: 47
Practical: 28

Prerequisites: None
Co-requisites: None

Evaluation Structure:

Theory Testing	45%
Practical Exercises	25%
Final Assessment	30%

Number: S0382.1

Title: Control Systems

Duration: Total Hours 55

Theory: 35
Practical: 20

Cross-Reference to Training Standard Performance Objectives: 6424.0, 6425.0, 6426.0, 6427.0, 6428.0, 6429.0, 6430.0, 6431.0, 6432.0, 6433.0, 6434.0

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to assemble and test control systems and components commonly found in industry.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

3.1.1 Identify and describe control system types and applications.

- Common industry controls such as:
  - Combustion controls
  - Heating Ventilation and Air Conditioning controls (HVAC)
  - Boiler Controls
  - Power Plant Controls

- Computer Controls
  - Distributed controls
  - Supervisory controls
  - Data acquisition
  - Direct digital controls
  -

3.1.2 Describe the features and applications of cascade controls.

- Cascade control features
- Cascade control applications
- Prepare loop drawings of cascade controls

3.1.3 Describe the features and applications of ratio controls.

- Ratio control features
- Ratio control applications
- Prepare loop drawings of ratio controls

3.1.4 Describe the features and applications of feed-forward controls.

- Feed – forward control features
- Feed – forward control applications
- Prepare loop drawings of feedforward controls

3.1.5 Assemble and test control systems such as:

- Cascade Control Loop
- Ratio Control Loop

Number: S0382.2

Title: Computer Controls and Data Transfer Methods

Duration: Total Hours 10

Theory: 10
Practical: 0

Cross-Reference to Training Standard Performance Objectives: 6431.01, 6431.02, 6431.03, 6431.04, 6431.05, 6431.06, 6431.07, 6431.08

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to describe computer controls and data transfer methods of common industry applications.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

3.2.1 Define computer and microprocessor – based controller terminology.

3.2.2 Identify various types and limitations of Network Topologies and Protocols.

Number:	S0382.3	
Title:	Controller Tuning	
Duration:	Total Hours	5
	Theory:	2
	Practical:	3

Cross-Reference to Training Standard Performance Objectives: 6431.02, 6431.04, 6431.06, 6431.07

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to tune controllers using a variety of methods according to approved industry standards.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

3.3.1 Identify various methods of controller tuning.

3.3.2 Tune controllers using a variety of tuning methods.

- Calculate Controller Settings
- Tune Controllers using various prescribed methods
- Implement auto tune if available.

Number: S0382.4

Title: Troubleshooting Controller Systems

Duration: Total Hours 5

Theory: 0
Practical: 5

Cross-Reference to Training Standard Performance Objectives: 6423.09, 6431.02, 6431.04

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to troubleshoot controller systems to rectify common system problems.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

3.4.1 Troubleshoot controller systems.

- Identify equipment and determine problems using loop diagrams.
- Recognize symptoms and their typical causes.

S0382: RECOMMENDED MINIMUM EQUIPMENT:

- PLC (Programmable Logic Controller) – minimum 6 discrete inputs, 4 discrete outputs, 2 analog inputs, 2 analog outputs
- DCS (Distributed Control System) – minimum 6 discrete inputs, 4 discrete outputs, 2 analog inputs, 2 analog outputs
- DMM, lead wire
- DC power supply
- AC power source
- Personal computer for program entry c/w PLC software, network card
- Variety of input devices – manual and automatic switches, 4 – 20 mA transmitters
- Variety of output devices – lights, motors, relays and solenoids, 4 – 20 mA loads such as I/P
- Network cables, hub or router
- Variety of standalone PID controllers
- Standard screwdrivers, Phillips screwdrivers, prototype board, side cutters, wire stripper, soldering iron
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, DC amps (0 – 2A),
  AC amps (0 – 10A)
- Variable DC power supply – 0 to 40 Vdc
- Instrumentation calibrators (amperage, voltage, etc.)
- SMART instrumentation communicators (HART, Fielbus etc)

Number: **S0383**

Title: **Analytical Instrumentation**

Duration: Total Hours: 36

Theory: 30
Practical: 6

Prerequisites: None
Co-requisites: None

Evaluation Structure:

Theory Testing	60%
Practical Exercises	10%
Final Assessment	30%

Number: S0383.1

Title: Introduction to Analyzers and Analytic Process Measurement

Duration: Total Hours: 24

Theory: 24
Practical: 0

Cross-Reference to Training Standard Performance Objectives: 6432.01, 6432.02, 6432.03

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to describe the operating principles of analyzers related to analytical process measurement.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

4.1.1 Describe the principles and operations of Analyzers such as:

- PH/ORP and Conductivity
- Turbidity
- Humidity
- Oxygen Analyzer
- Opacity Analyzer
- Chromatography
- Spectroscopy
- Vibration
- Solid Moisture Analyzer
- Thermal Conductivity
- Radiant Energy Absorption

Number: S0383.2

Title: Analyzer Sampling Systems

Duration: Total Hours: 6

Theory: 6
Practical: 0

Cross-Reference to Training Standard Performance Objectives: 6432.01, 6432.02, 6432.03

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to describe the fundamentals of analyzer sampling systems according to the manufacturer's design.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

4.2.1 Identify the necessary components for an analyzer sampling System.

4.2.2 Identify the requirements for a proper sampling system.

4.2.3 Describe the function of analyzer sampling systems.

Number: S0383.3

Title: Analyzer Calibration and Maintenance

Duration: Total Hours: 6

Theory: 0
Practical: 6

Cross-Reference to Training Standard Performance Objectives: 6432.01, 6432.02, 6432.03

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to calibrate a variety of analyzers and describe recommended maintenance procedures.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

4.3.1 Describe the maintenance procedures for analyzers.

4.3.2 Calibrate analyzers using prescribed procedures.

S0383: RECOMMENDED MINIMUM EQUIPMENT:

- Standard screwdrivers, Phillips screwdrivers, prototype board, side cutters, wire stripper, soldering iron
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, DC amps (0 – 2A),
  AC amps (0 – 10A), Ohms
- Variety of an .ers such as pH/ORP, conductivity, DO, turbidity, etc
- Calibration standards such as buffer solutions, sample gases, etc
- Manufacturer's data sheets
- Analyzer operation manuals

Number: **S0384**

Title: **Fluid Power Systems**

Duration: Total Hours 30

Theory: 22
Practical: 8

Prerequisites: None
Co-requisites: None

Evaluation Structure:

- Assignments related to theory and appropriate application skills.
- Final exam at end of term.
- Periodic quizzes.

Theory Testing	65%
Practical Exercises	5%
Final Assessment	30%

Number: S0384.1

Title: Fundamentals of Fluid Power Systems

Duration: Total Hours 4

Theory: 4
Practical: 0

Cross-Reference to Training Standard Performance Objectives: 6422.03, 6428.04, 6428.05, 6428.06, 6429.04, 6429.05, 6429.06, 6429.17, 6429.18

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to demonstrate the ability to describe the fundamentals and applications, draw symbols and identify the hazards of industrial fluid power systems according to manufacturer's recommendations.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

5.1.1 Define the fundamentals of Fluid Power Systems.

- Define fluid power in terms of energy transmission
- State the advantages and disadvantages of hydraulics and pneumatics
- Define basic principles for force, work and power.
  - weight and specific gravity
  - pressure, force and area
  - static pressure
  - gauge pressures in English and Metric units
  - Pascal's Law and Bernoulli's principle
  - conversion of energy and fluid power
  - pressure losses
- Identify hydraulic servo control systems

5.1.2 Draw fluid power system valve symbols to ISO and ANSI standards.

5.1.3 Identify the hazards and safety concerns of fluid power systems.

Number: S0384.2

Title: Hydraulic Systems

Duration: Total Hours 10

Theory: 10
Practical: 0

Cross-Reference to Training Standard Performance Objectives: 6422.03, 6429.17, 6429.18

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to demonstrate the ability to describe the operating principles of industrial hydraulic systems according to the manufacturer's design.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

5.2.1 Describe the construction features, types and applications of hydraulic systems.

5.2.2 Describe the operating principles of hydraulic systems and components.

- Hydraulic pumps
- Hydraulic plungers and cylinders
- Hydraulic control valves
- Flow control devices
- Pressure switches
- Pressure gauges
- Fans
- Storage tanks

Number: S0384.3

Title: Pneumatic Systems

Duration: Total Hours 10

Theory: 5
Practical: 5

Cross-Reference to Training Standard Performance Objectives: 6422.03, 6428.04, 6428.05, 6428.06, 6429.04, 6429.05, 6429.06

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to demonstrate the ability to assemble and test industrial pneumatic systems according to manufacturer's recommendations and specifications.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

5.3.1 Describe the use and applications of pneumatic systems.

- Pneumatic system air supply
  - compressors
  - motors
  - filters
  - dryers
- Pneumatic system components such as:
  - pipes and fittings
  - filters
  - dryers
  - receivers
  - cylinders
  - pressure regulators
  - gauges
  - intensifiers
  - controllers and recorders
  - sensors
  - pneumatic tools

5.3.2 Explain the operating principles of pneumatic systems and components such as:

- Air supply systems
- Air flow control circuits
- Air filtering, drying and oiling
- Pressure and flow gauges
- Determine the function and layout of pneumatic circuits

5.3.3 Assemble and test basic pneumatic systems.

Number: S0384.4

Title: Hydraulic and Pneumatic

Duration: Total Hours 6

Theory: 3
Practical: 3

Cross-Reference to Training Standard Performance Objectives: 6429.17, 6429.18

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to demonstrate the ability to assemble and test hydraulic and pneumatic control circuits of industrial systems according to the manufacturer's design.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

5.4.1 Identify fluid power circuits and component graphic symbols.

5.4.2 Assemble basic hydraulic and pneumatic circuits.

5.4.3 Test hydraulic and pneumatic control circuits.

S0384: RECOMMENDED MINIMUM EQUIPMENT:

- Pipe, instrument tubing and fittings
- Pneumatic cylinders
- Pressure Regulating Valves (PRV)
- Pressure gauges
- Standalone pneumatic controllers and recorders
- Variety of pneumatic sensors

Summary of Equipment Required for Level III

S0380: Recommended Minimum Equipment:

- Standard screwdrivers, Phillips screwdrivers, prototype board, side cutters, wire stripper, soldering iron
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, DC amps (0 – 2A),
  AC amps (0 – 10A)
- Variable DC power supply – 0 to 40 Vdc
- Variety of capacitors, inductors, transformers
- Oscilloscope and X10 probe
- AC source – 120 vac
- Assorted resistors
- Prototype board – Circuit assembly
- Clamp-on ammeter
- Lead wire
- Variety of diodes, bridge rectifiers, voltage regulators
- Variety of final control elements (Triacs, SCRs, VFD, etc)
- Operational amplifiers
- Optocouplers
- Variety of relays, contactors,

S0381: Recommended Minimum Equipment:

- PLC (Programmable Logic Controller) – minimum 6 discrete inputs, 4 discrete outputs, 2 analog inputs, 2 analog outputs
- DCS (Distributed Control System) – minimum 6 discrete inputs, 4 discrete outputs, 2 analog inputs, 2 analog outputs
- DMM, lead wire
- DC power supply
- AC power source
- Personal computer for program entry c/w PLC software, network card
- Variety of input devices – manual and automatic switches, 4 – 20 mA transmitters
- Variety of output devices – lights, motors, relays and solenoids, 4 – 20 mA loads such as I/P
- Network cables, hub or router

S0382: Recommended Minimum Equipment:

- PLC (Programmable Logic Controller) – minimum 6 discrete inputs, 4 discrete outputs, 2 analog inputs, 2 analog outputs
- DCS (Distributed Control System) – minimum 6 discrete inputs, 4 discrete outputs, 2 analog inputs, 2 analog outputs
- DMM, lead wire
- DC power supply
- AC power source
- Personal computer for program entry c/w PLC software, network card
- Variety of input devices – manual and automatic switches, 4 – 20 mA transmitters
- Variety of output devices – lights, motors, relays and solenoids, 4 – 20 mA loads such as I/P
- Network cables, hub or router
- Variety of standalone PID controllers
- Standard screwdrivers, Phillips screwdrivers, prototype board, side cutters, wire stripper, soldering iron
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, DC amps (0 – 2A),
  AC amps (0 – 10A)
- Variable DC power supply – 0 to 40 Vdc
- Instrumentation calibrators (amperage, voltage, etc.)
- SMART instrumentation communicators (HART, Fielbus etc)

S0383: Recommended Minimum Equipment:

- Standard screwdrivers, Phillips screwdrivers, prototype board, side cutters, wire stripper, soldering iron
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, DC amps (0 – 2A),
  AC amps (0 – 10A), Ohms
- Variety of analyzers such as pH/ORP, conductivity, DO, turbidity, etc
- Calibration standards such as buffer solutions, sample gases, etc
- Manufacturer's data sheets
- Analyzer operation manuals

S0384: Recommended Minimum Equipment:

- Pipe, instrument tubing and fittings
- Pneumatic cylinders
- Pressure Regulating Valves (PRV)
- Pressure gauges
- Standalone pneumatic controllers and recorders
- Variety of pneumatic sensors